Fame EPOS Re-Scope Review

Fame EPOS Downsizing

Action	Savings
-- Solar Array Size Reduced -- BOL Pout Reduced From 1110W to 570W. # Cells Reduced From 2160 to 1121	~ $353K
-- Battery Size Reduced -- Battery Capacity Reduced From 55AH to 22AH	~ $288K

Fame EPOS Electronics Re-Scope Trades

Trade	Delta $ vs Inst PDR
-- Single String vs Redundant Design	Single String Saves ~ $160K
-- Electronics Design Changes	Saves ~ $20K
-- New vs Heritage Hardware	Heritage Hardware Saves ~ $200K
-- One Proto-Flight PCDE vs One Brassboard + One Flight PCDE	One Proto-Flight PCDE Saves ~ $230K
	Saves ~ $610,000

Fame EPS Electronics Re-Scope Specifics

Issue	Status at Inst PDR	Status at Re-Scope	Re-Scope Delta vs PDR
Redundancy	Redundant Battery Chargers	Single Battery Charger	Save 2 CCAs Save $100K ($25K+$75K)
	Redundant Motor Drivers	Single Motor Driver	Save 1 CCA Save $25K
	Redundant HSKP P.S.	Single HSKP P.S.	Save 1 CCA Save $25K
	Redundant Serial Cmd	Single Serial Cmd	Save 1/4 CCA Save $10K
			Saves ~ $160K
Design Changes	Closed Loop Heater Cntrl	Open Loop Heater Cntrl	Save 1 CCA Save $20K

Fame EPS Electronics Re-Scope Specifics

Issue	Status at Inst PDR	Status at Re-Scope	Re-Scope Delta vs PDR
New vs Heritage Hardware	All New Hardware	Use/Mod Existing ICM Hardware: 1) Solar Array Switch 2) Charger Control 3) Housekeeping Power Supply 4) IMU Power Supply	Save 4 New Designs & 6 New CCAs Savings ~ $200K
PCDE Boxes	1 Brassboard + 1 Flight Box	1 Proto-Flight Box	Savings ~ $230K

Fame EPS Re-Scope Total Savings

-- Solar Array Size Reduced	~ $353K
-- Battery Size Reduced	~ $288K
-- Electronics Design,Build Mods	~ $610K
	Total Savings = $1,251K

EPOS Design Baseline

-- 8 Cell, 22AH Li-Ion Battery

-- 570Watt, 1121 GaInP/GaAs/Ge Cell Solar Array

-- One Proto-Flight, Single-String PCDE

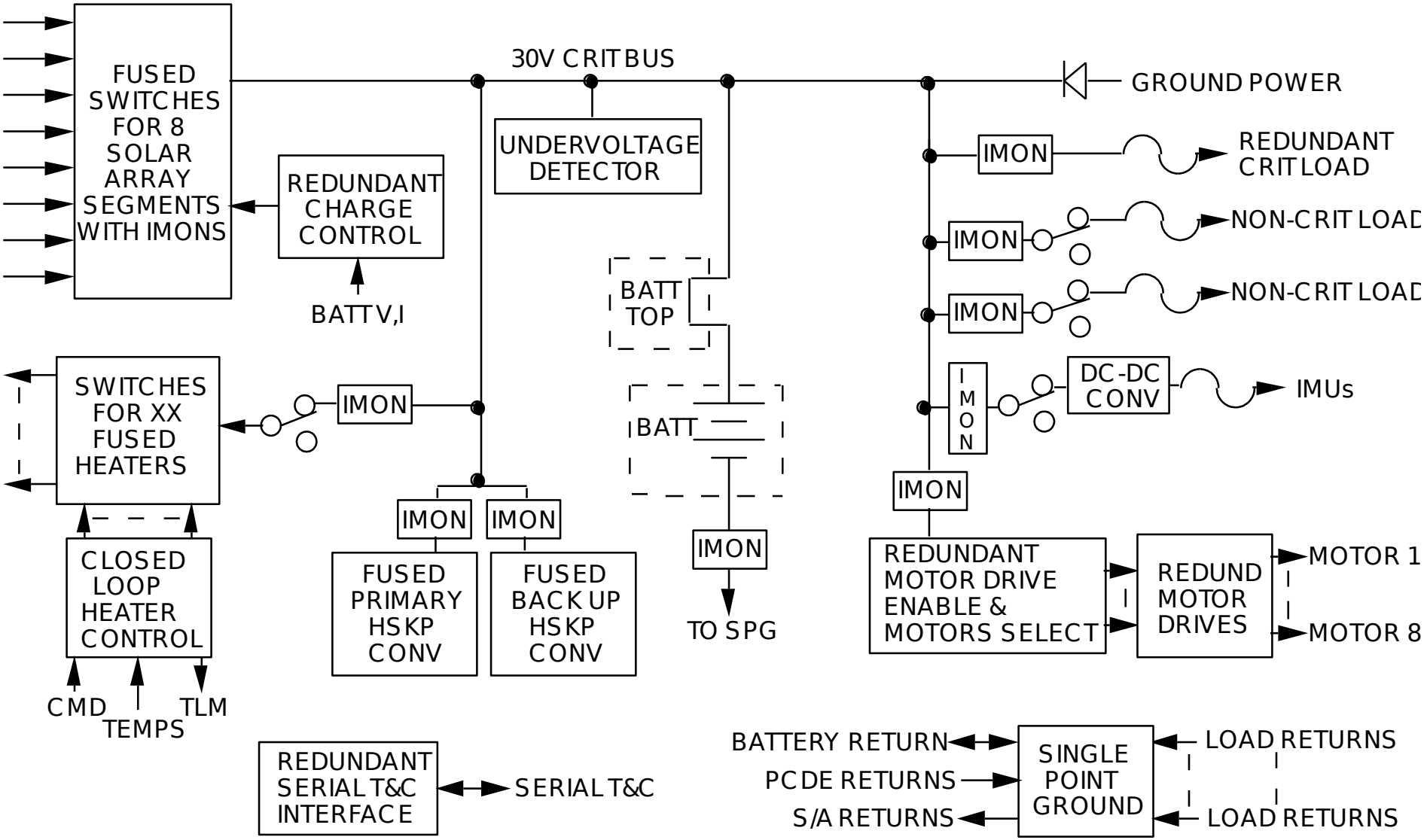
-- One Proto-Flight Ordnance Box

-- One Proto-Flight Solar Array J-Box

-- One Flight Inboard Harness

-- One Flight Outboard Harness

POWER CONTROL & DISTRIBUTION ELECTRONICS DESIGN @ INSTRUMENT PDR



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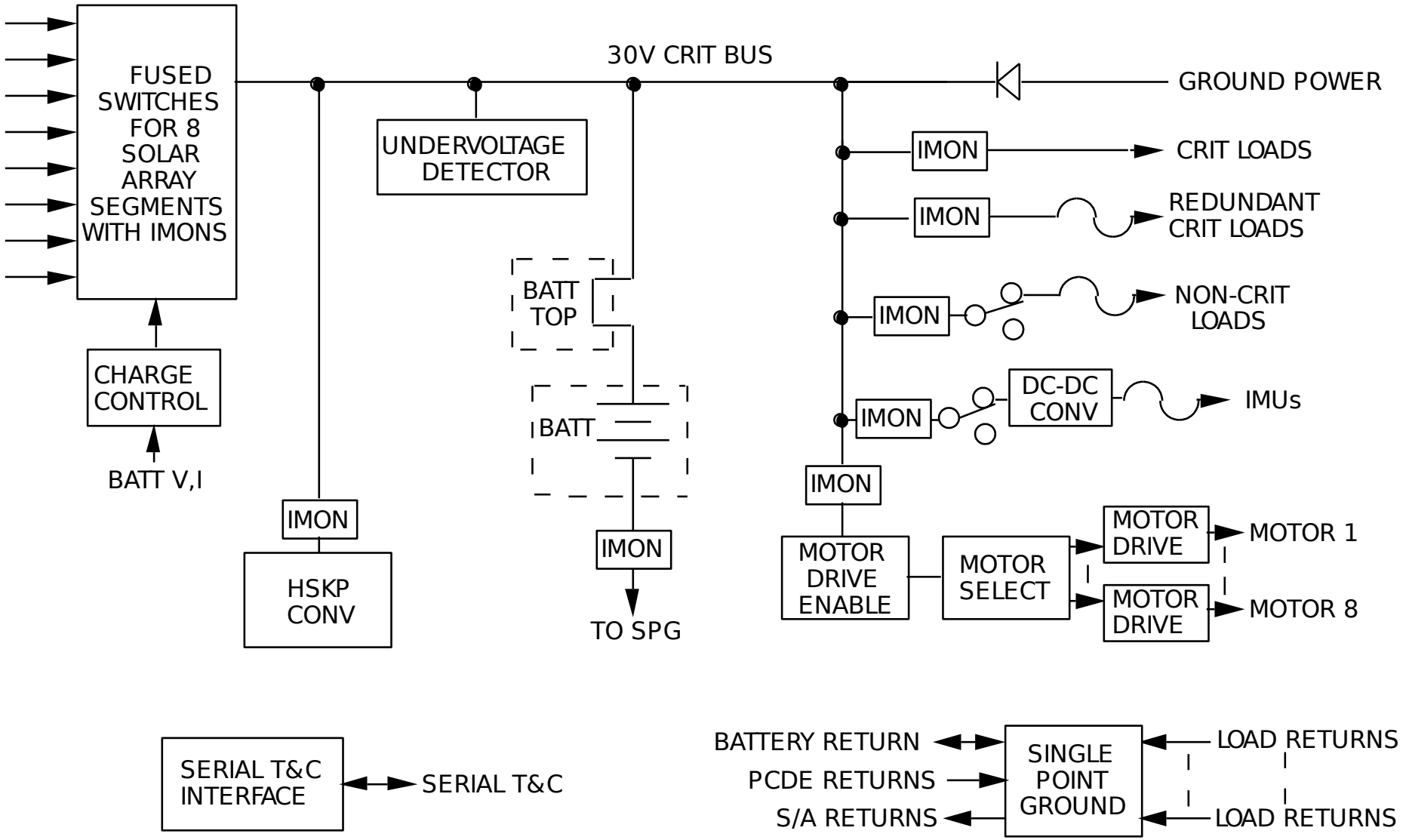
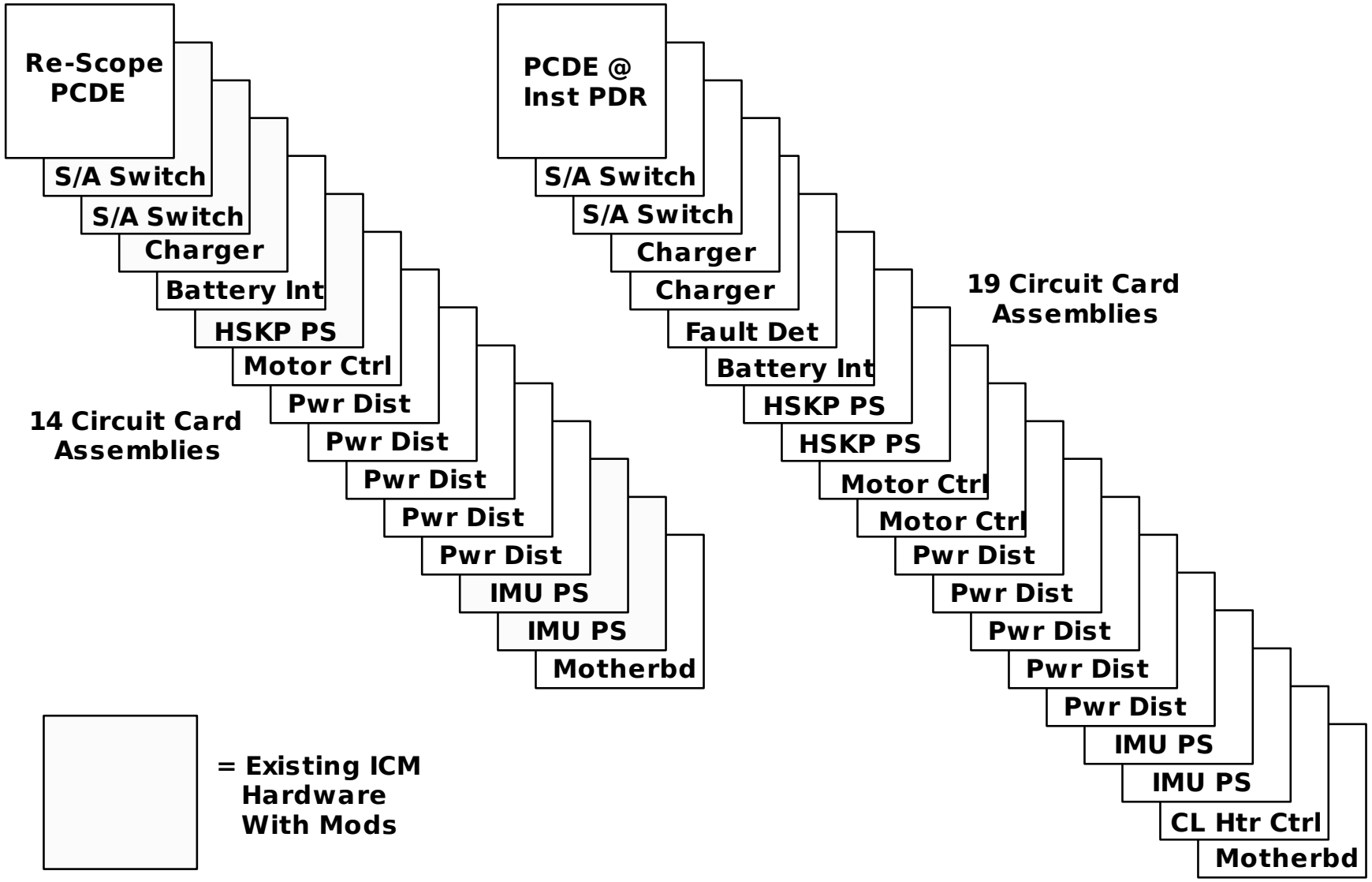
POWER CONTROL & DISTRIBUTION ELECTRONIC DE-SCOPE DESIGN



PCDE CCA Comparison



FAME Solar Array Design Re-Scope

Instrument PDR

- Pwr Required = 1060 W @ 30V
- Six Deployable Panels
- GaInP/GaAs/Ge 26.5% Solar Cells
- 40˚C Operating Temperature
- N_s = 18 (Series Cells/String)
- N_p = 120 (Parallel Strings)
- N_T = 2160 Cells
- BOL P_{out} = 1208 W @ 30 V
- EOL P_{out} = 1180 W @ 30 V

Spacecraft Bus Re-Scope

- Pwr Required = 425 W @ 30 V
- Fixed Ring Shaped Substrate
- GaInP/GaAs/Ge 26.5% Solar Cells
- 80˚C Operating Temperature
- N_s = 19 (Series Cells/String)
- N_p = 59 (Parallel Strings)
- N_T = 1121 Cells
- BOL P_{out} = 606 W @ 30 V
- EOL P_{out} = 594 W @ 30 V

FAME Energy Storage System Re-Scope

Instrument PDR

- Energy Required = 1236 Wh
- Max. DOD = 80%
- Battery Capacity = 55 Ah
- Number of Cells = 8
- Battery Voltage = 24 - 33.6 VDc
- Mass = 16.25 kg (35.82 lbs)
- Volume = 253.5 in^3

Spacecraft Bus Re-scope

- Energy Required = 496 Wh
- Max. DOD = 80%
- Battery Capacity = 22 Ah
- Number of Cells = 8
- Battery Voltage = 24 - 33.6 VDc
- Mass = 6.498 kg (14.33 lbs)
- Volume = 164.06 in^3

FAME EPS User History

CSR	Instrument PDR	Re-Scope
FSC A/B	FSC A/B	FSC A/B
	RIU	RIU
IMUA	IMUA	IMUA
IMUB	IMUB	IMUB
SunSensor	SunSensor	SunSensor
StarTracker A	StarTracker A	StarTracker A
StarTracker B	StarTracker B	StarTracker B
TransponderA	Transponder A	Transponder A
Transponder B	Transponder B	Transponder B
SSPA	SSPA	
Trim Tabs Motors	Trim Tabs Motors	Trim Tabs Motors
Trim Mass Motors	Trim Mass Motors	Trim Mass Motors
	Trim Area Motors	Trim Area Motors
	X-Axis Electromagnetic Torque Rod	X-Axis Electromagnetic Torque Rod
	Y-Axis Electromagnetic Torque Rod	Y-Axis Electromagnetic Torque Rod
	Z-Axis Electromagnetic Torque Rod	Z-Axis Electromagnetic Torque Rod
	Magnetometer	Magnetometer
	Spin Control Heaters	
Thermal Control Heaters (5)	Thermal Control Heaters (42)	Thermal Control Heaters (42)
Ordnance Control Box	Ordnance Control Box	Ordnance Control Box
	Star Tracker Cover Motors	Star Tracker Cover Motors
	Instrument Aperature Cover Motors	Instrument Aperature Cover Motor
Instrument Electronics A	Instrument DPA-A	Instrument DPA-A
Instrument Electronics B	Instrument DPA-B	Instrument DPA-B
	Instrument APA-A	
	Instrument APA-B	
Instrument Survival Heaters	Instrument Survival Heaters	Instrument Survival Heaters

FAME Power Budget Summary

Mission Phase Instrument State	*Launch* *Off*	*GTO* *Off*	*Super Syn* *Off*	*GEO-Early GEO* *Boot, Standby*	*GEO-Science* *Boot, Stndby, O*	*GEO-Science* *Focus*	*Safe-Hold Mod* *Survival*
Spacecraft Bus							
CTDH	27.10	39.50	39.50	39.50	39.50	39.50	27.1(
ADCS	1.25	21.25	31.25	45.55	35.55	35.55	25.5
RF	8.00	45.00	45.00	45.00	45.00	45.00	45.0(
EPS	15.00	37.00	37.00	38.00	71.00	38.00	18.0(
TCS	0.00	86.00	86.00	86.00	86.00	86.00	64.5(
Spacecraft Power By Operational Phase	51.35	228.75	238.75	254.05	277.05	244.05	180.1
25% Spacecraft Contingency	12.84	57.19	59.69	63.51	69.26	61.01	45.0
Total Spacecraft Power By Operational Phase	64.19	285.94	298.44	317.56	346.31	305.06	225.1
Instrument	0.00	60.00	60.00	135.50	135.50	165.50	55.0(
20% Instrument Contingency	0.00	12.00	12.00	27.10	27.10	33.10	11.0(
Total Instrument Power By Operational Phase	0.00	72.00	72.00	162.60	162.60	198.60	66.0(
Total Observatory Power W/Contingency	64.19	357.94	370.44	480.16	508.91	503.66	291.1
Solar Array Power Out	0.00	684.00	684.00	684.00	594.00	594.00	?
S/A Margin (W)		326.06	313.56	203.84	85.09	90.34	
S/A Margin (%)		91%	85%	42%	17%	18%	
					*	*	

***Solar Array Pwr Out at EOL, 80ÞC**

FAME Power Budget Details

			MISSION PHASE						
			Launch	GTO	Super Sync	GEO-Early GEO	GEO-Science	GEO-Science	Safe-Hold Mode
Instrument Mode			Off	Off	Off	Boot, Standby	Boot, Stndby, Op	Focus	Survival
Subsystem/Unit	Quantity	Pwr/Unit							
Command, Telemetry & Data Handling									
Fame Spacecraft Controller (FSC)	1		24.1	36.5	36.5	36.5	36.5	36.5	24.1
Remote Interface Unit (RIU)	1		3.0	3.0	3.0	3.0	3.0	3.0	3.0
CTDH Summary			27.1	39.5	39.5	39.5	39.5	39.5	27.1
Attitude Determination and Control									
IMU (Litton LN200)	2	10.0	0.0	20.0	20.0	20	10	10	10.0
Spinning Sun Sensor & Electronics (Adcole)	2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Star Tracker (Terma)	2	10.0	0.0	0.0	10.0	10.0	10.0	10.0	0.0
Electromagnetic Torquer (Ithaco)									
X,Y Axis	2	5.4	0.0	0.0	0.0	5.4	5.4	5.4	5.4
Z Axis	1	8.9	0.0	0.0	0.0	8.9	8.9	8.9	8.9
Thruster	8								
Spin Control Heaters	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Magnetometer (Ithaco)	2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
ADCS Summary			1.3	21.3	31.3	45.6	35.6	35.6	25.6
Radio Frequency Subsystem									
Transponder - Receiver	2	4.0	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Transponder - Transmitter	2	37.0	0.00	37.00	37.00	37.00	37.00	37.00	37.00
Solid State Power Amplifier	0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RF Summary			8.00	45.00	45.00	45.00	45.00	45.00	45.00
Mechanisms									
Trim Tab Motor	3		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trim Mass Motor	3		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trim Area Motors	3		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Star Tracker Cover Motors	2		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Instrument Aperature Cover Motors	2		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electrical Power Subsystem									
Power Control Distribution Electronics	1	0.0	15.0	37.0	37.0	38.0	71.0	38.0	18.0
Battery	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EPS Summary			15.0	37.0	37.0	38.0	71.0	38.0	18.0
Thermal Control Subsystem									
Star Tracker Htr	1	15	0.0	15.0	15.0	15.0	15.0	15.0	0.0
Electronics Deck Htr	1	65	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Magnetometer Htr	2	10	0.0	20.0	20.0	20.0	20.0	20.0	0.0
Instrument Interface Htr	1	20	0.0	20.0	20.0	20.0	20.0	20.0	0.0
Thruster Valve Htr	12	1.5	0.0	18.0	18.0	18.0	18.0	18.0	0.0
RCS Line Htr	1	20	0.0	0.0	0.0	0.0	0.0	0.0	20.0
RCS Tank Htr	1	20	0.0	0.0	0.0	0.0	0.0	0.0	20.0
Sun Sensors Htr	4	3	0.0	0.0	0.0	0.0	0.0	0.0	12.0
Trim Area Motor Htr	3	3	0.0	0.0	0.0	0.0	0.0	0.0	9.0
Trim Tab Motor Htr	3	3	0.0	0.0	0.0	0.0	0.0	0.0	9.0
AKM Motor Htr	1	60	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CATBED Htrs	12	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCS Summary			0.0	86.0	86.0	86.0	86.0	86.0	64.5
Spacecraft Power By Operational Phase			51.35	228.75	238.75	254.05	277.05	244.05	180.15
25% Spacecraft Contingency			12.8	57.2	59.7	63.5	69.3	61.0	45.0
Total Spacecraft Power By Operational Phase			64.2	285.9	298.4	317.6	346.3	305.1	225.2
Instrument									
Electronics									
Focal Plane Assembly			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Camera Control Assembly			0.0	0.0	0.0	0.0	0.0	0.0	0.0
Analog Processor Assembly A	1	72	0.0	0.0	0.0	72.0	72.0	72.0	0.0
Analog Processor Assembly B	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Data Processor Assembly	1	51	0.0	0.0	0.0	51.0	51.0	51.0	0.0
Operational Heaters									
Focal Plane Heater			0.0	15.0	15.0	1.67	1.7	1.7	4.2
Structure Heater			0.0	5.0	5.0	10.8	10.8	10.8	10.8
Survival Heater			0.0	40.0	40.0	0.0	0.0	0.0	40.0
Focus Motors			0.0	0.0	0.0	0.0	0.0	30.0	0.0
Instrument Power By Operational Phase			0.0	60.0	60.0	135.5	135.5	165.5	55.0
20% Instrument Contingency			0.0	12.0	12.0	27.1	27.1	33.1	11.0
Total Instrument Power By Operational Phase			0.0	72.0	72.0	162.6	162.6	198.6	66.0
Total Observatory Power W/O Contingency				288.8	298.8	389.6	412.5	409.6	235.2
Total Observatory Power W/Contingency			**64.2**	**357.9**	**370.4**	**480.2**	**508.9**	**503.7**	**291.2**

On-Going Trade Studies

-- Lithium-Ion vs Nickel-Hydrogen Battery

FAME Energy Storage Trade

CSR Baseline

- Nickel Hydrogen
- 12, Two Cell Batteries*
- Capacity = 25 Ah
- Battery Voltage 24 - 36 VDc
- Volume = 1714 in^3 (28100 cm^3)
- Mass = 18.33 kg (40.41 lbs)
- *includes 1 spare CPV
- Manufacturers : Eagle Picher

Current Re-scope

- Lithium Ion
- Number of Cells = 8
- Battery Capacity = 22 Ah
- Battery Voltage = 24 - 33.6 VDc
- Volume = 164.06 in^3 (2689 cm^3)
- Mass = 6.498 kg (14.33 lbs)
- Manufacturers: Yardney, SAFT, Eagle Picher, Others
- Battery Cell Bypass Electronics
  - Mass = 3.175 kg (7.0 lbs)
  - Volume = 256 in^3 (4196 cm^3)

Lithium Ion w/battery cell bypass electronics saves 19 lbs & 1400 in^3